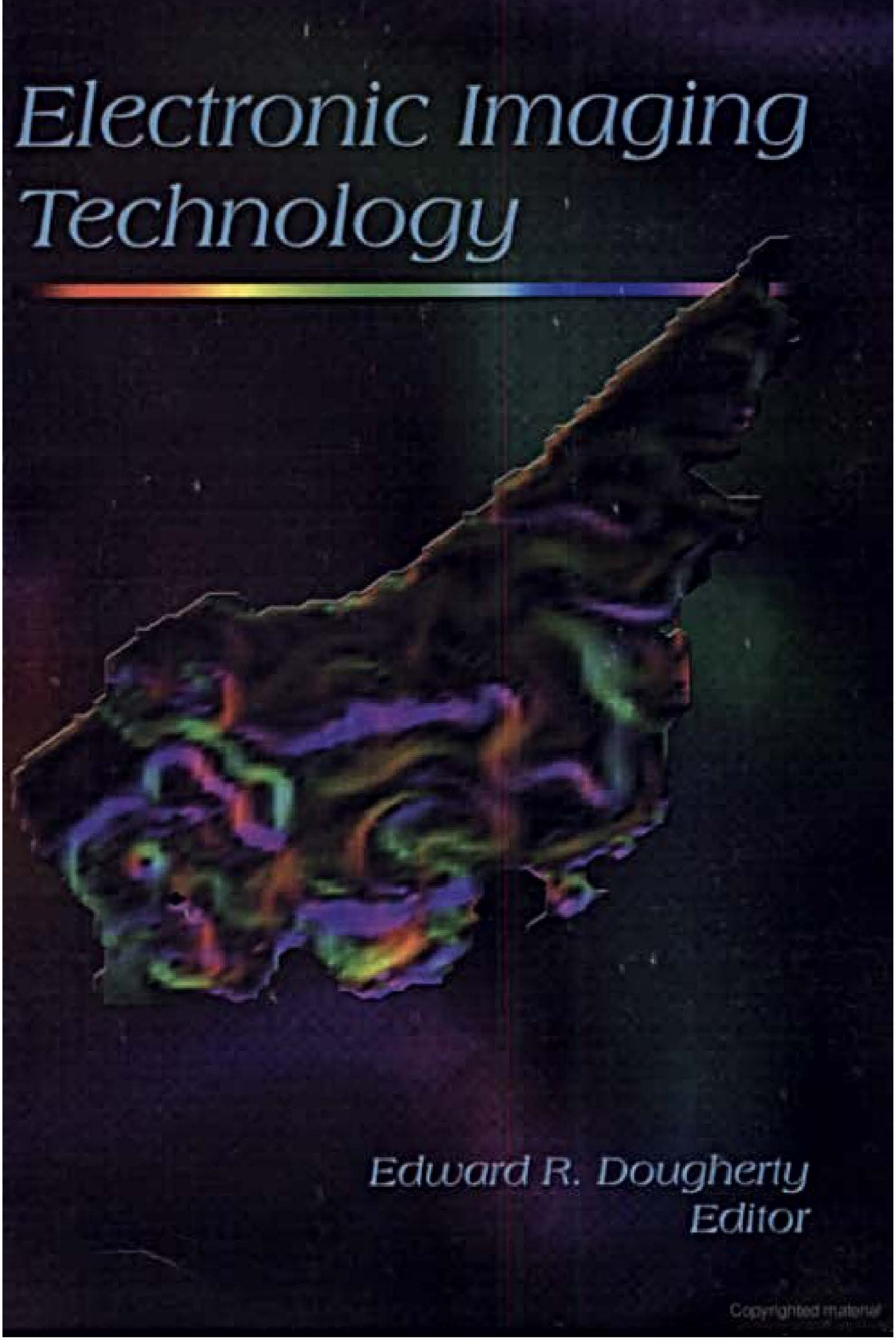
Exhibit A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- surface data sets in which the dependent variable(s) may be scalars like pressure, temperature, viscosity, surface coverage or vectors like flow velocity, wind speed/direction, or a gradient.
- census data sets in which the scalars may be age, education, income, race, sex, religion, etc.

Examples of common 3D data sets include:

- medical data sets for which the dependent variable may be density (scalar), blood velocity (vector), or air velocity (vector). Figure 4.14 contains two visualizations of density data.
- oceanographic data sets for which the dependent variables might include temperature, salinity, 2D or 3D currents, or 2D sea surface height fields. Figure 4.15 contains five visualizations of 2D currents.
- atmospheric data sets for which the dependent variables might include wind velocity, wind stress, surface pressure, accumulated precipitation, terrain height, solar radiation, heat flux, temperature, and potential temperature.

If the data are defined on a structure and the sampling is at a fixed interval, we are able to store the data in a more compact form. The relationship between data points, i.e., the structure of the data, also affects interpolation schemes and error analysis. The data must be structured—or a structure created—to use visualization algorithms which operate on cells or cubes.

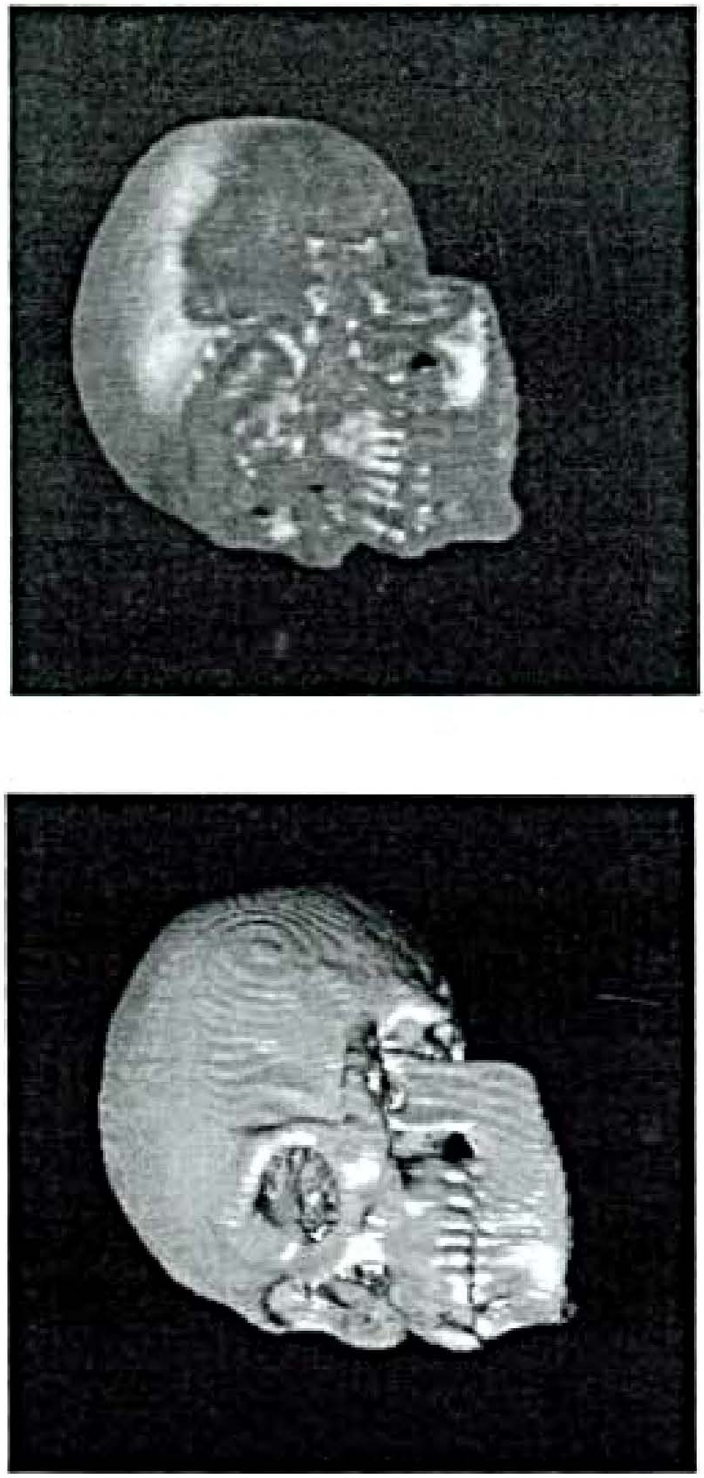
4.2.3 Mappings

There are a number of mappings from data to images. In fact, we often go through a number of stages of mapping. The choice of mapping is influenced by the data, the problem or physical phenomenon being studied, the question or issue being addressed, the audience, and the purpose of the visualization (to demonstrate something or to convince someone).

4.2.3.1 Color mapping or pseudo coloring

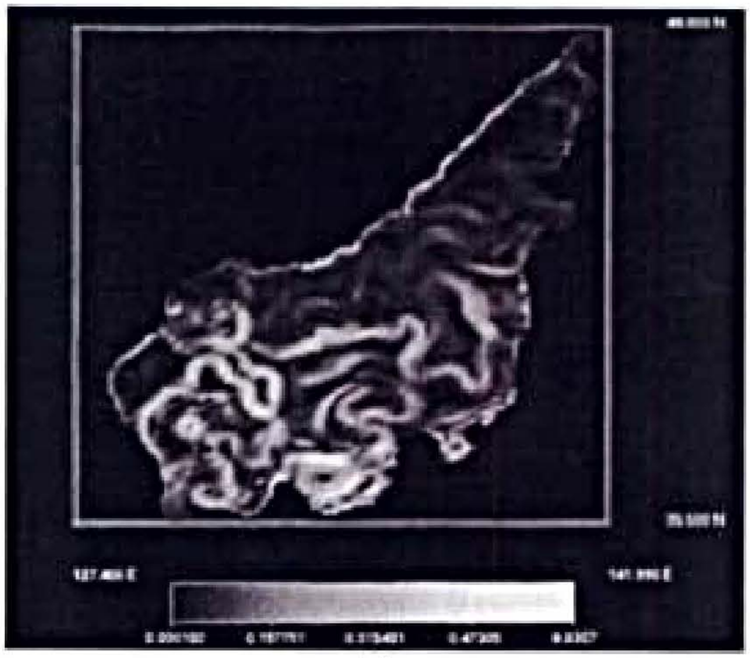
Color mapping maps data to colors. Most often the mapping is applied to scalar data, but schemes exist to map multiple variables to different components of color.

For scalar color mapping, the mapping is implemented by using the scalar values as indices into a list of colors. This is called a *color lookup table* or LUT. We may choose to map only part of the range of scalar values or we may map all of the scalar values into only part of the color lookup table. This allows the user to trade-off precision and range, since the

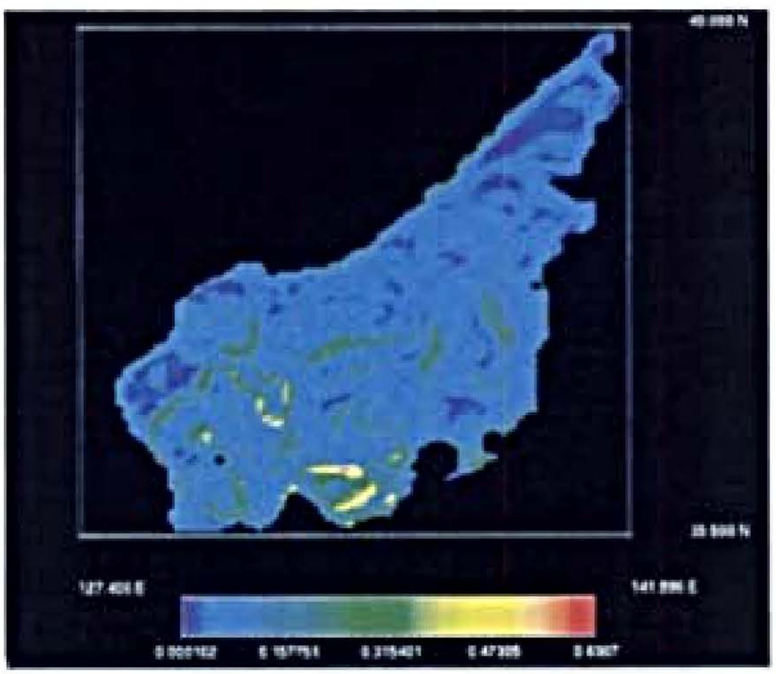


(a) (b)

Figure 4.14 Comparison of density data rendered as a) an isosurface and b) a volume rendering.

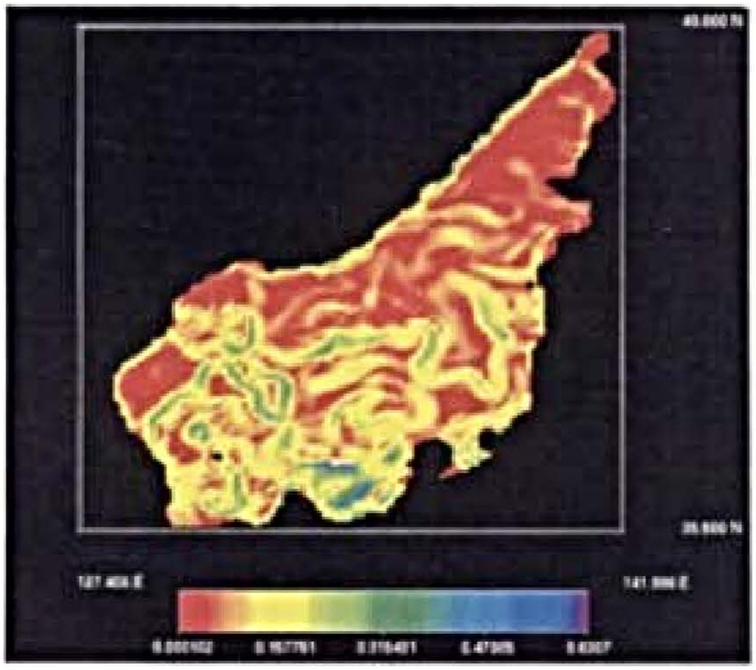


(a)

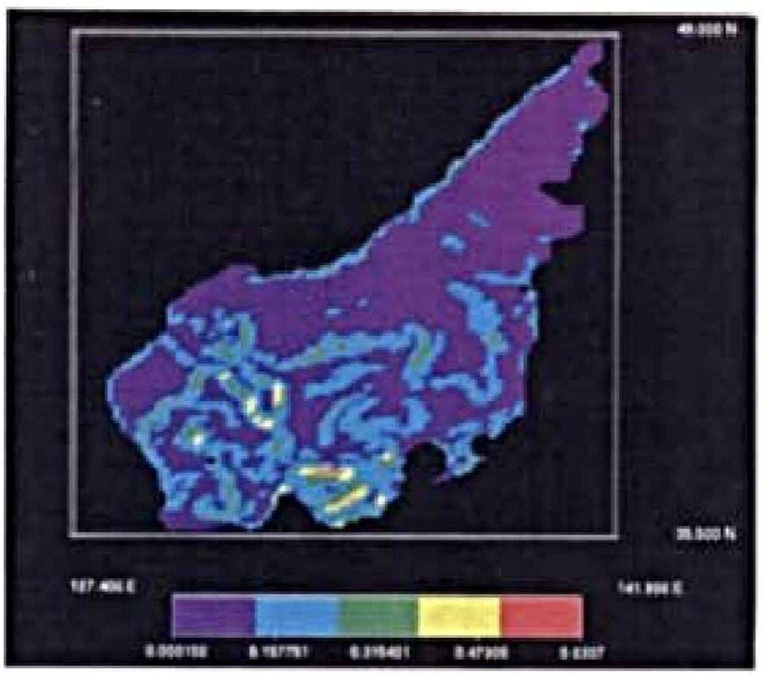


(b)

Figure 4.15 Modeled sea surface height in the Sea of Japan on January 17, 1981. a) grayscale, b) rainbow (blue to red). Data courtesy of the Naval Research Lab, Stennis Space Center, MS.

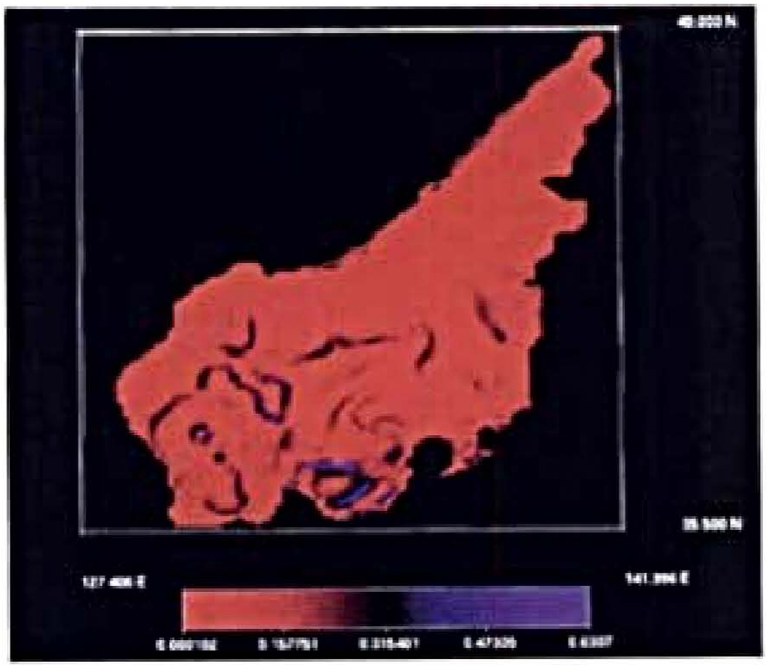


(c)



(d)

Figure 4.15 Modeled sea surface height in the Sea of Japan on January , 1981, c) rainbow (red to blue), d) banded. Data courtesy of the Naval Research La Stennis Space Center, MS.



(e)

Figure 4.15 Modeled sea surface height in the Sea of Japan on January 17, 1981. e) double-ended. Data courtesy of the Naval Research Lab, Stennis Space Center, MS.

human visual system can only distinguish 20,000 to 30,000 colors simultaneously. Thus, it may be desirable to only map a subrange of scalar values into the color lookup table, map the values below the subrange to one constant color, and map the values above the subrange to another constant color. This allows the viewer to examine a range of scalar data with greater precision. This may be useful when there are a number of outliers in the data set or when one particular range of values is of particular interest. Other alternatives include allowing color re-use, i.e., colors may not represent unique values or value ranges, but may be context dependent.

Figure 4.15 shows five different lookup tables (colormaps) used to indicate flow speed in the Sea of Japan. Figure 4.15a is a grayscale map, in which the slowest flow is black, the mean flow is mid-level gray, and the fastest flow is white. In 4.15b the hues mimic a rainbow going from blue to red, while in 4.15c the hues once again mimic a rainbow, but go from red to blue. In 4.15d the banded color map displays ranges of scalar values as a constant color. Many oceanographers claim this allows them to see the structure better due to the well-defined breaks. In 4.15e the double-ended colormap shows flow slower than the median speed in red and faster than the median speed in blue. There is a smooth (linear) transition from black to saturated blue or red. This mapping is often used for data sets whose range includes zero.